Express Mailing No. EV241979035US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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Applic No.:		
Filed : Herewith		Group Art Unit:
For : APPARATUS AND METHOD FOR MONITORING BODY COMPOSITION BY MEASURING BODY DIELECTRIC CONSTANT AND BODY IMPEDANCE BASED ON THE METHOD OF FREQUENCY DIGITAL SAMPLING		Examiner:
Docket No.: R74.12-0001		

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Sir:

Applicant claims right of priority under the provisions of 35 USC § 119 based on European Patent Application No. 02028205.9, filed December 14, 2002.

A certified copy of this application is enclosed. This priority application is identified in the Declaration filed herewith.

Applicant requests that priority be granted on the basis of this application.

Respectfully submitted,

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The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. **Patent application No.** **Demande de brevet n°**

02028205.9

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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Anmeldung Nr:
Application no.: 02028205.9
Demande no:

Anmeldetag:
Date of filing: 14.12.02
Date de dépôt:

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Apparatus and method for monitoring body composition by measuring body dielectric constant and body impedance based on the method of frequency digital sampling

In Anspruch genommene Prioriät(en) / Priority(ies) claimed /Priorité(s) revendiquée(s)
Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/
Classification internationale des brevets:

A61B5/05

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of filing/Etats contractants désignées lors du dépôt:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR IE IT LI LU MC NL PT SE SI SK

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APPARATUS AND METHOD FOR MONITORING BODY COMPOSITION BY MEASURING BODY DIELECTRIC CONSTANT AND BODY IMPEDANCE BASED ON THE METHOD OF FREQUENCY DIGITAL SAMPLING

FIELD OF THE INVENTION

The present invention relates to measurement devices in general, and more particularly to a body composition monitor by measuring dielectric constant of body endermic tissues and body impedance based on the method of frequency digital sampling.

BACKGROUND OF THE INVENTION

Body composition refers to the total contents consisting of every tissue and organ of human's body, its total weight is namely body weight, which is composed of two parts: fat and non-fat content. The former mass is called body fat mass, the ratio between it and body mass is called percent body fat (Fat %) in human body. The latter includes the weight of water, viscera, bones, muscle, mineral salts and so on, and is also called lean body mass or fat free mass, among which water content accounts for most of the mass. 70% fat content is mainly distributed in and below the region of waist.

Body composition indicates the rates of body tissue structure such as lean body mass (LBM) and body fat. Different tissue body structure contents result in different body functions and activity, and in order to maintain the body's normal functions, it is required that all contents adjust to one another at certain rates. Once the maladjusted rates destroy the normal physiological functions and activity, the normal growth and health of the body will be affected. Body composition can also indicate physical attributes, body shape characteristic and body stature, and fat content can indicate body fitness. So body composition is significant to make the fitness standard and body shape assessment and so on.

There are already some methods and fruits for measuring body fat content alone, such as isotope dilution method, underwater weighing method, height and weight empirical algorithms, ultrasound measurement, infrared measurement and so on. All these methods have the shortcomings of complicated equipment and inconvenient operation.

There are three indices for measuring body water content: total body water (TBW), intracellular water (ICW) and extracellular water (ECW). TBW equals the sum of ICW and ECW, and these three indices are significant to assess the physical attributes and the balance status of intracellular and extracellular liquid. There are also corresponding methods for measuring body water. The method often used is druggery dilution method. For example, to take certain doses of antibilin or D_2O, after these medical substances disperse uniformly to global body, to extract some sample of blood and urine for testing. Also there is a method called multiple-factor isotope dilution, which can measure multiple body contents including water content from microcosmic aspect. None of these methods presented above can meet the demand of fast and integrated monitoring of body weight, fat and water content. Especially some methods of medical substance dilution, can only be done in hospitals, have long time period, cost much and can not be done as often as needed.

The method of bioelectrical impedance analysis (BIA) is considered to be the simplest method for measuring human body composition (such as fat content). This method is based upon the principle that body tissue conductivity of bio electricity in different region of body stimulated

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by outside electricity is different. For example, the conductivity of muscle is high and then the impedance is small because of its high rate of water content, while the conductivity of fat tissue, bone tissue and lung tissue filled with air is very low and the impedance is relatively great. So body composition can be estimated according to tissue's impedance. Up to now, though those open patents on measuring body composition based on bioelectrical impedance analysis (BIA) adopt different circuits, arithmetic, apparatus structures and different output methods, they have three common characteristic in nature, the first is to obtain bioelectric impedance by measuring voltage or voltage difference then transforming to digital value through A/D, the second is to use at least more than three electrodes (groups), among which two electrodes is certain to apply high frequency small current to human body in order to stimulate bio electricity and the other two electrodes collect stimulated voltage signal indicating bioelectrical impedance, if unite two of four electrodes to be used as reference electrodes, then there are 3 electrodes, the third is that the different frequency signals applied to human body must be signals with determined frequencies. As disclosed in U.S. Pat. No.6, 151, 523, bioelectrical impedance can be measured by placing electrodes at a person's toes and heels, and by inputting the weight and height of the subject, percent body fat can also be estimated. The shortcomings of the above methods are: first, the methods have limitation if body fat and water content are determined based on bioelectrical impedance alone, second, because of the great diversity of human bodies, if only one or multiple determined frequencies are applied to human body, the results can not indicate body status accurately, third, there are large error in those low-cost apparatus when use voltage measurement to determine body impedance.

OBJECTS OF THE INVENTION

The present invention aims to solve those questions above, the object is to provide a method for measuring dielectric constant of body endermic tissues by using capacitance sensor contacting body skin and based on the method of frequency digital sampling.

The present invention also aims at providing a method according to which, human body is connected with oscillator circuit as a two end impedance element, then generates unfixed frequencies related to body impedance, and by sampling frequency, the digital signal, the body impedance is determined.

The present invention also aims to provide a method of determining body composition by jointly using measurement of two parameters: dielectric constant of body endermic tissues and body impedance.

The present invention also aims to provide a body composition monitor for measuring body dielectric constant and body impedance based on the method of frequency digital sampling, and the monitor is used to monitor body composition in everyday life.

SUMMARY OF THE INVENTION

The present invention includes two kinds of measuring modes and corresponding apparatus for composition monitoring. The first mode is to assemble the measuring unit and display unit in an integrative apparatus. The apparatus includes feet-on electrode plates and capacitance grid sensor, both of which are attached to the platform of weighing scale, body impedance and water measuring circuits, weighing sensor, weighing signal process circuit, microprocessor system, display, keyboard, and so on. Before measurement, the subject's gender, height and age are input

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by keyboard. The measuring results including body weight, fat content, water content and so on are shown on the display. The second mode is measuring unit and display unit are separated as measuring apparatus and display apparatus physically. The measuring apparatus includes feet-on electrode plates and capacitance grid sensor, both of which are attached to the platform of weighing scale, weighing sensor, infrared signal emitting and receiving circuit, microprocessor system, body impedance and water test circuit, weighing signal process circuit and so on. The display apparatus consists of infrared signal emitting and receiving circuit, microprocessor system, display, keyboard and so on. Before measurement, the subject's gender, height and age are input by keyboard of display apparatus. Measuring apparatus emits the results of weight, fat content, water content by infrared signal transmitting circuit to display apparatus hand-held or hung up on wall, and the results are shown on display.

Because the dielectric constant of body endermic tissues is related directly to the fat content and water content of body tissues, the present invention regards the dielectric constant of body endermic tissues as a measuring parameter for evaluating body composition. The present invention's method and principle for measuring dielectric constant of body endermic tissues is: when a testee stands with barefoot on the measuring platform, his soles of two feet contact two capacitance grid sensors, and the oscillator circuit connected with capacitance grid sensors generates oscillating frequency signals related to dielectric constant of body endermic tissues, the signals are sampled and then the dielectric constant of body endermic tissues can be obtained.

Because body impedance is related directly to the fat content and water content of body tissues, the present invention regards the body impedance as a measuring parameter for evaluating body composition. The present invention's method and principle for measuring body impedance is: when a testee stands with barefoot on the measuring platform, his two feet contact two (groups of) electrode plates mounted on the platform simultaneously and respectively. At this time human body is connected with oscillator circuit as a two ends impedance element and a loop is formed at and below human's waist region. The oscillating frequency of the oscillator circuit is related to the impedance of human body. By changing parameters of other elements of oscillator circuit, several different frequency signals are obtained related to body impedance, then the body impedances corresponding to several different frequencies are determined.

The method and principle of the present invention to determine body composition by jointly using measurement of the two kinds of measuring parameters, dielectric constant of body endermic tissues and body impedance, is to introduce to math models the dielectric constant of body endermic tissues, the body impedance, body weight obtained from weighing sensor and circuit, and the input data by keyboard, to calculate by microprocessor, and to display body weight, body fat content, total body water (TBW) and the ratio between intracellular water and TBW (ICW/TBW) by display.

The math models for calculating these data are as follows:

$$\text{Fat} = \frac{a_1H + a_2W + a_3R_{m1} + a_4R_{m2} + a_5R_{m3} + a_6Y + a_0}{ce^{-(b_1H+b_2W)}}$$

$$\text{Fat}(\%) = \frac{\text{Fat}}{W}$$

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$$TBW=\frac{Fat+K_1\varepsilon_r}{K_2\varepsilon_r}+K_3$$

where W is body weight (Kg), Rm1, Rm2, Rm3 are body impedance corresponding respectively to three kinds of undetermined frequencies. ε_r is the dielectric constant of body endermic tissues; Fat is body fat value(kg); Fat(%) is percent body fat; H is body height (cm); Y is a subject's age, a_0、a_1、a_2、a_3、a_4、a_5、a_6、b_1、b_2、c、K1、K2、K3、K4 are all coefficients, whose values are related to gender. Among these parameters, , W 、Rm1、Rm2 、Rm3、ε_r are determined by measurement, H、Y and gender are input by keyboard.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig1A is a schematic view showing the mode of assembling the function units of measuring and displaying body composition in an integrative apparatus.

Fig1B is a schematic view showing the mode of separating the function units of measuring and displaying body composition to measuring apparatus and display apparatus physically.

Fig2A shows an embodiment example of measuring platform configuration of the integrative apparatus based on the mode shown in Fig1A.

Fig2B shows an alternative embodiment example of measuring platform configuration of the integrative apparatus based on the method shown in Fig1A.

Fig3A shows the system configuration based on the integrative apparatus shown in Fig2A.

Fig3B shows the system configuration based on the integrative apparatus shown in Fig2B.

Fig4A shows an embodiment example of measuring platform configuration of measuring apparatus based on the mode shown in Fig1B.

Fig4B shows an alternative embodiment example of measuring platform configuration of measuring apparatus based on the mode shown in Fig1B.

Fig5A is a schematic view showing the system configuration based on the measuring apparatus shown in Fig4A.

Fig5B is a schematic view showing the system configuration based on the measuring apparatus shown in Fig4B.

Fig6 is a schematic view showing the platform configuration of display apparatus based on the measuring mode shown in Fig1B.

Fig7A is a schematic view showing the first kind of electrode configuration of capacitance grid sensor measuring the dielectric constant of body endermic tissues.

Fig7B is a schematic view showing the second kind of electrode configuration of capacitance grid sensor measuring the dielectric constant of body endermic tissues.

Fig7C is a schematic view showing the third kind of electrode configuration of capacitance grid sensor measuring the dielectric constant of body endermic tissues.

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Fig7D is a schematic view showing the fourth kind of electrode configuration of capacitance grid sensor measuring the dielectric constant of body endermic tissues.

Fig8 is a schematic view showing the measuring mode of measuring the dielectric constant of body endermic tissues and body impedance by applying undetermined frequencies through sole.

Fig9 is a schematic diagram showing the circuit system structure of measuring the dielectric constant of body endermic tissues and body impedance by using undetermined frequencies.

Fig10 is a schematic diagram showing the positive feedback RC oscillator circuit for measuring the dielectric constant of body endermic tissues in the positive feedback RC oscillator circuit for measuring the dielectric constant of body endermic tissues and body impedance.

Fig11 is a schematic view showing the circuit for measuring the body impedance in the positive feedback RC oscillator circuit for measuring dielectric constant of body endermic tissues and body impedance.

Fig12 is an alternative schematic view showing the circuit for measuring the body impedance in the positive feedback RC oscillator circuit for measuring dielectric constant of body endermic tissues and body impedance.

Fig13 is a schematic diagram showing circuit structure based on the display apparatus shown in Fig6.

Fig14 is a schematic diagram showing the configuration of infrared signal transmitting circuit in measuring apparatus based on the measuring mode shown in Fig 1B.

Fig15 is a schematic diagram showing the configuration of infrared signal transmitting circuit in display apparatus based on the measuring mode shown in Fig 1B.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Fig1A, The first measuring mode is to assemble the measuring function unit and display function unit into a integrative apparatus. A testee stands with barefoot on the platform **1** of the integrative apparatus attaching feet-on electrode plates and capacitance grid sensor. The testee's data are input by keyboard **2** of the integrative apparatus. The determined results by measurement including weight, fat content and water content are shown on display **3**.

Referring now to Fig1B, The second mode is that the measuring function unit and display function unit are separated as measuring apparatus and display apparatus physically. There are microprocessors in both the measuring apparatus and display apparatus, and data are transmitted between the two apparatus by the transmitting manner of infrared **7**. A testee stands with barefoot on the platform **4** of measuring apparatus attaching foot-on electrode plates and capacitance grid sensor. The testee's data are input by display apparatus **6** held in hand by the testee. Measuring apparatus emits determined data including body weight, body fat ratio and body water ratio in infrared **7** transition manner through window **5** to display apparatus and then these data are shown here.

There are two embodiment examples of the measuring platform configuration of the integrative apparatus in the present invention.

Referring now to Fig2A, it shows a kind of measuring platform configuration of integrative apparatus based upon the measuring mode shown in Fig1A. The platform **1** is positioned on scale sensor. The surface of the platform **1** is insulative and, there are two electrodes **8, 9** on the platform, which have enough area to be contacted by human's sole and are made of conductive materials. There is no conduction between electrodes **8** and **9**, between electrodes **8, 9** and

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platform **1**. Also on the platform **1** there is at least more than one capacitance grid sensors **10, 11**, which are used to measure the dielectric constant body endermic tissues and can be contacted by human's soles. Keyboard **2** and display **3** are located on platform **1**.

Referring now to Fig2B, it shows another kind of measuring platform configuration of integrative apparatus based upon the measuring mode shown in Fig1A. The platform **101** is positioned on scale sensor. The surface of the platform **101** is insulative, and there are two electrodes **12, 13** comprising electrode plates connected by conducting wires on the platform **101**. There is no conduction between electrodes **12** and **13**, between electrodes **12,13** and platform **101**. Also on the platform there are at least one or more capacitance grid sensors **10, 11**, which can be contacted by human's soles. Keyboard **2** and display **3** are located on platform **101**.

Referring now to Fig3A, it shows the system configuration of integrative apparatus shown in Fig2A. Electrode plates **8, 9** and capacitance grid sensors **10, 11** are connected with the interfaces of positive feedback RC oscillator circuit **14** for measuring the dielectric constant of body endermic tissues and body impedance, and positive feedback RC oscillator circuit **14** for measuring the dielectric constant of body endermic tissues and body impedance is connected with two interfaces of microprocessor MCU system **15** of the integrative apparatus. One of the two interfaces is a signal collection interface of MCU system **15** of the integrative apparatus, the other is a control interface of MCU system **15** of the integrative apparatus used to send switch instruction to positive feedback RC oscillator circuit **14** for measuring the dielectric constant of body endermic tissues and body impedance in order to switch undetermined multiple frequencies and measuring signals of the dielectric constant of body endermic tissues. The signal wires of weighing sensor **19** are connected with weighing signal process circuit **18**, and the processed signal is applied to one interface of the MCU system **15** of the integrative apparatus through weighing signal processing circuit **18**. Display **16** is connected with the output of MCU system **15** of the integrative apparatus and is used to show the input data and the measuring result. Keyboard **17** is connected with the I/O interface of MCU system **15** of the integrative apparatus and is used to input data to MCU system **15** of the integrative apparatus.

Referring now to Fig3B, it shows the system configuration of integrative apparatus shown in Fig2B.The two groups of electrode **12, 13** composed of electrode plates connected with one another by wires and being able to contact human's soles, and capacitance grid sensor **10, 11** are connected with the interfaces of positive feedback RC oscillator circuit **14** for measuring the dielectric constant of body endermic tissues and body impedance, and positive feedback RC oscillator circuit **14** for measuring the dielectric constant of body endermic tissues and body impedance is connected with two interfaces of MCU system **15** of the integrative apparatus. One of the interfaces is the signal collection interface of MCU **15** system of the integrative apparatus and the other is a control interface of the MCU system **15** of the integrative apparatus used to send switch instruction to positive feedback RC oscillator circuit **14** for measuring the dielectric constant of body endermic tissues and body impedance in order to switch undetermined multiple frequencies and the measuring signal of body dielectric constant of endermic tissues. The signal wires of weighing sensor **19** are connected with weighing signal process circuit **18**, and the processed signal is applied to one interface of MCU system **15** of the integrative apparatus through weighing signal processing circuit **18**. Display **16** is connected with the output of MCU system **15** of the integrative apparatus and is used to show the input data and the measuring results. Keyboard **17** is connected with the I/O interface of MCU **15** and is used to input data to MCU **15**.

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Referring now to Fig4A, it shows a kind of measuring platform configuration of measuring apparatus based upon the measuring mode shown in Fig1B. The platform 4 is positioned n scale sensor, and on the platform 4, there are two electrodes 8, 9 with enough area to be contacted by human's sole. Also on the platform 4 there are at least one or more capacitance grid sensors 10, 11 which can be contacted by human's soles and are used to measure dielectric constant of the body endermic tissues. Infrared ray transmitting window 5 is positioned on measuring platform 4.

Referring now to Fig4B, it shows another kind of measuring platform configuration of measuring apparatus based upon the measuring mode shown in Fig1B. The platform 401 is positioned on scale sensor, and on the platform 401, there are two groups of electrode 12, 13 comprising electrode plates connected by conducting wires and with enough area to be contacted by human's soles. Also on the platform 401 there are at least one or more capacitance grid sensors 10, 11 which can be contacted by human's soles and are used to measure dielectric constant of the body endermic tissues. Infrared ray transmitting window 5 is positioned on measuring platform 401.

Referring now to Fig5A, it shows the system configuration of measuring apparatus shown in Fig4A. Electrodes 8, 9 and capacitance grid sensor 10, 11 are connected with the interfaces of positive feedback RC oscillator circuit 14 for measuring the dielectric constant of body endermic tissues and body impedance, and positive feedback RC oscillator circuit 14 for measuring the dielectric constant of body endermic tissues and body impedance is connected with two interfaces of microprocessor MCU system 20 of measuring apparatus. One of the two interfaces is a signal collection interface of MCU system 20 of measuring apparatus, the other is a control interface of MCU system 20 of measuring apparatus used to send switch instruction to positive feedback RC oscillator circuit 14 for measuring the dielectric constant of body endermic tissues and body impedance in order to switch undetermined multiple frequencies and measuring signal of dielectric constant of body endermic tissues. The signal wires of weighing sensor 19 are connected with weighing signal process circuit 18, and the processed signal is applied to one interface of MCU system 20 of the measuring apparatus through weighing signal processing circuit 18. The determined data by measurement are emitted or received by infrared ray-emitting- receiving circuit 21.

Referring to Fig5B, it shows the system configuration of measuring apparatus shown in Fig4B.Two groups of electrodes 12, 13, which are composed of electrode plates connected with one another by wires and can be in contact with human's soles, and capacitance grid sensors 10, 11 are connected with the interfaces of positive feedback RC oscillator circuit 14 for measuring the dielectric constant of body endermic tissues and body impedance, and positive feedback RC oscillator circuit 14 for measuring the dielectric constant of body endermic tissues and body impedance is connected with two interfaces of MCU 20 system of the measuring apparatus. One of the interfaces is the signal collection interface of MCU 20 system of the measuring apparatus and the other is a control interface of MCU system 20 of the measuring apparatus used to send switch instruction to positive feedback RC oscillator circuit 14 for measuring the dielectric constant of body endermic tissues and body impedance in order to switch undetermined multiple frequencies and the measuring signal of dielectric constant of body endermic tissues. The signal wires of weighing sensor 19 are connected with weighing signal process circuit 18, and the processed signal is applied to one interface of MCU system 20 of the measuring apparatus through weighing signal processing circuit 18. The determined data by measurement are emitted or

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received by infrared ray-emitting- receiving circuit 21.

Referring now to Fig6, it shows the surface configuration of display apparatus based upon the measuring mode shown in Fig1B. On the process panel of display apparatus 6 are keyboard 2, display 3 and infrared ray transmitting window 22.

In the present invention, there are four embodiment examples of capacitance grid sensor for measuring the dielectric constant of body endermic tissues.

Referring now to Fig7A, the capacitance grid sensor for measuring the dielectric constant of body endermic tissues is composed of two non-intersectant electrodes 23.

Referring now to Fig7B, the two groups of electrodes 24 of the capacitance grid sensor for measuring the dielectric constant of body endermic tissues are dentiform, nested and non-intersectant.

Referring now to Fig7C, the two groups of electrodes 25 of the capacitance grid sensor for measuring the dielectric constant of body endermic tissues are equidistant, and circle outward from the circular or rectangular center, and the two groups of electrodes are never intersectant.

Referring now to Fig7D, the electrodes 26 of capacitance grid sensor for for measuring the dielectric constant of body endermic tissues are equidistant and non-touching plates, and are connected by conductors to become two equidistant and non-touching electrode groups.

Referring now to Fig8, it shows a measuring method, wherein the subject is connected to the circuit as an impedance element Rm for measuring body impedance and dielectric constant of body endermic tissues. The testee's two feet contact two (groups of) electrode plates 27 simultaneously and respectively. Then the human body is connected as a two end impedance element Rm with positive feedback RC oscillator circuit 14 for measuring the dielectric constant of body endermic tissues and body impedance, and a loop is formed at and below the human body waist region. The oscillating frequency of the oscillator circuit is related to the impedance element Rm. By changing parameters of other elements of oscillator circuit, several different frequency signals are obtained related to body impedances, then the body impedances corresponding to several different frequencies are determined. When the testee's foot soles contact two capacitance grid sensors 28, capacitor Cm is formed, and the positive feedback RC oscillator circuit 14 for measuring the dielectric constant of body endermic tissues and body impedance connected with Cm generates oscillating frequency signals related to dielectric constant of body endermic tissues, then this kind of frequency digital signals are dealt with by sampling and the dielectric constant of body endermic tissues is determined.

Referring now to Fig9, it shows the system configuration of circuit for measuring dielectric constant of body endermic tissues and body impedance by using undetermined frequencies. Human body impedance Rm is coupled to the positive feedback RC oscillator circuit 14 for measuring the dielectric constant of body endermic tissues and body impedance, capacitor Cm formed by capacitance grid sensor together with capacitors C1,C2,...Cn, which are different in values, are introduced to switch circuit 30. Switch circuit 30 is introduced to the positive feedback RC oscillator circuit 14 for measuring the dielectric constant of body endermic tissues and body impedance. By switching C1, C2,...Cn in circuit 30 to the positive feedback RC oscillator circuit 14 for measuring the dielectric constant of body endermic tissues and body impedance, oscillating signals of multiple undetermined frequencies related to Rm are generated, then body impedances can be measured corresponding to different frequencies. By switching circuit 30 Cm is introduced to the positive feedback RC oscillator circuit 14 for measuring the dielectric constant of body

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endermic tissues and body impedance and dielectric constant of body endermic tissues can be measured. The principle is described as follows:

When C1 is introduced to the positive feedback RC oscillator circuit **14** for measuring the dielectric constant of body endermic tissues and body impedance, the output frequency of oscillating signal is:

$$f_1 = \frac{K}{R_m C_1}$$

When C1 and Cm are in parallel connection and introduced to the positive feedback RC oscillator circuit **14** for measuring the dielectric constant of body endermic tissues and body impedance, the output frequency of oscillating signal is

$$f_2 = \frac{K}{R_m (C_1 + C_m)}$$

Then can get

$$C_m = \frac{C_1 (f_1 - f_2)}{f_2}$$

While dielectric constant of body endermic tissue, ε_r can be gotten by following equation

$$\varepsilon_r = \frac{C_m \delta}{\varepsilon_0 A}$$

where δ is the electrode distance of capacitance grid sensor, ε_0 is vacuum dielectric constant; A is electrode area forming the capacitance of capacitance grid.

Referring now to Fig**10**, it is a schematic view showing the circuit for measuring the dielectric constant of body endermic tissues in the positive feedback RC oscillator circuit for measuring dielectric constant of body endermic tissues and body impedance. The circuit is made up of two invertors, capacitor Ca, resistor Ra, body impedance Rm and capacitance grid sensor Cm in contact with human's soles. The connection between capacitance grid sensor Cm and capacitor Ca is in series, and the other ends of the series circuit are respectively connected with the output end of one invertor and input end of the other invertor. The connection between Ra and Rm is in series, and and the other ends of the series circuit are respectively connected with the input end and the output end of one invertor. The input end of one invertor is connected with the output end of the other invertor.

Referring now to Fig**11**, it is a schematic view showing the circuit for measuring the body impedance in the positive feedback RC oscillator circuit for measuring dielectric constant of body endermic tissues and body impedance. The circuit comprises two invertors, resistor Ra, capacitor Ca and body impedance Rm. The capacitance grid sensor Cm is a short-circuit capacitance in the circuit. The input end of one invertor is connected with the output end of the other invertor, between the joint of the two invertors and the input end of the invertor, the series-wound circuit comprised by resistor Ra and body impedance Rm is introduced. The two ends of the capacitor Ca are connected respectively with the two invertors' two ends that are not connected with each other. The oscillating frequency of the oscillator circuit can change with the different body impedance

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Rm.

Referring now to Fig12, it is a schematic view showing another kind of circuit for measuring the body impedance in the positive feedback RC oscillator circuit for measuring dielectric constant of body endermic tissues and body impedance. The circuit comprises one D trigger, resistors Ra1 and Ra2, capacitor Ca1 and body impedance Rm. The body impedance Rm is in series connection with resistor Ra1 and then in parallel connection with resistor Ra2. The one end of the circuit in series-parallel connection is connected with the invert end of the D trigger, and another end is connected with the CD end, CLK end, and GND end of the D trigger. The oscillating frequency of the oscillator circuit can change with the different body impedance Rm.

Referring now to Fig13, it shows the circuit system based upon the display apparatus shown in Fig6. Keyboard **34**, display **35** and infrared emitting-receiving circuit **32** are all connected with corresponding interfaces of MCU system **31** of the display apparatus.

Referring now to Fig14, it shows the configuration of infrared signal transmitting circuit configuration of measuring apparatus based upon the measuring mode shown in Fig1B. Electrical signal is input from the base electrode of audion T1, the collectors of audion T1 and T2 are connected with one port of infrared emitter **36**, and the other port of infrared emitter **36** is connected with current-limiting resistor R1, infrared emitter **36** emits infrared data signal **7**. Infrared receiver **38** receives the infrared instruction signal emitted by display apparatus when operated, and converts the infrared signal to electrical signal, which is then transmitted from infrared receiver **38** to the base electrode of audion T3. The collector of audion T3 is connected with the input level of decoder **37**. The output level of decoder **37** is connected with MCU system **20** of the measuring apparatus. This circuit makes measuring apparatus realize the two-direction transition of infrared signal.

Referring now to Fig15, it shows the configuration of infrared signal transmitting circuit in display apparatus. Infrared receiver receives the data signal emitted from measuring apparatus, and the data signal is converted to electrical signal, which is then transmitted from infrared receiver **29** to the base electrode of audion T7. The collector of audion T7 is connected with the interface of MCU system **31** of the display apparatus. The interface of MCU system **31** of the display apparatus sends electrical signal to the input interface of encoder **39**, whose output interface is connected with the base electrode of audion T5. The collectors of audion T5 and T6 are connected with one port of infrared emitter **33**, and the other port of infrared emitter **33** is connected with current-limiting resistor R4. Infrared emitter **33** emits infrared instruction signal **7**. This circuit makes display apparatus realize the two-direction transition of infrared signal.

The advantages of the present invention are: 1. To jointly evaluate body composition by using the two measuring parameters of body impedance by measurement and the dielectric constant of body endermic tissues measured by the capacitance grid sensor in contact with the human body's skin, so to decrease the uncertainty caused by assessment using only one measured parameter; 2. To measure the body impedance and dielectric constant of body endermic tissues based on the method of frequency digital sampling, so to leave out the A/D converting part and to improve the measuring accuracy; 3. To measure body impedance by using non-fixed multiple frequency method, so to make the body difference to be indicated more obviously in body impedance difference and to indicate the body composition status genuinely. The apparatus of the present invention is used to conveniently monitor the body composition in everyday life.

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WHAT IS CLAIMED IS:

1. A kind of method for measuring dielectric constant of body endermic tissues and body impedance based on the method of frequency digital sampling and for evaluating body composition, comprising the following steps of:

getting the body weight frequency signal of a testee standing on the platform to measure body weight;

making the positive feedback RC oscillator circuit connected with two ends of capacitance grid sensor generate oscillating frequency related to dielectric constant of body endermic tissues by positioning testee's soles to contact the capacitance grid sensor on the measuring platform;

making the positive feedback RC oscillator circuit connected with two (groups of) electrode plates generate oscillating frequency related to body impedance by positioning testee's soles to contact the two (groups of) electrode plates with certain area on the measuring platform;

introducing the switched capacitors with different capacitance values to the said positive feedback RC oscillator circuit to get several oscillating signals with non-fixed different frequencies related to body impedance;

inputting by keyboard the testee's serial number, height, age, gender, and parameter indicating whether or not an athlete;

through the I/O interface of the microprocessor inputting the measured body weight frequency signals, oscillating frequency signals related to dielectric constant of body endermic tissues and body impedance signals corresponding to non-fixed different frequencies;

through the software of the microprocessor calculating the body fat content, total body water, ratio between intracellular water and total body water;

displaying the body weight, body fat content; total body water and ratio between intracellular water and total body water on the display.

2. The method according to claim 1, wherein: one end of the said capacitance grid sensor Cm in contact with human's soles is connected with one end of capacitor Ca; and the other ends of the Cm and Ca is respectively connected with the output end of one invertor and input end of the another invertor; and the input end of one invertor is connected with the output end of the another invertor; and wherein oscillating frequency signals related to dielectric constant of body endermic tissues is generated.

3. A method according to claim 1, wherein: the input end of one invertor is connected with the output end of the other invertor; and between the joint of the two invertors and the input end of one invertor, the series-wound circuit comprised by resistor Ra and body impedance element Rm is introduced; and the two ends of the capacitor Ca are connected respectively with the two invertors' two ends which are not connected with each other; and wherein oscillating frequency signals related to body impedance is generated.

4. A method according to claim 1, wherein: the body impedance element Rm is in series connection with resistor Ra1 and then in parallel connection with resistor Ra2; the one end of the circuit in series-parallel connection is connected with the invert end of the D trigger; and the another end is connected with the CD end, CLK end, and GND end of the D trigger; and wherein oscillating frequency signals related to body impedance is generated.

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5. A method according to claim 1, comprising the step of: introducing body impedance element Rm to said positive feedback RC oscillator circuit; switching and introducing C1, C2, ...Cn to said positive feedback RC oscillator circuit; getting several oscillating signals with non-fixed different frequencies related to body impedance Rm.

6. A body composition monitor for measuring dielectric constant of body endermic tissues and body impedance based on the method of frequency digital sampling, comprising measuring unit, which comprises weighing sensor and weighing signal processing circuit, and display unit; wherein the said monitor also includes the said positive feedback RC oscillator circuit for measuring dielectric constant of body endermic tissues and body impedance, the two (groups of) foot-on electrode plates on the platform; at least more than one capacitance grid sensors, microprocessor, display and keyboard; wherein:

the said foot-on electrode plates and capacitance grid sensor are connected with the said positive feedback RC oscillator circuit;

the said positive feedback RC oscillator circuit, weighing signal processing circuit are in electrical connection with microprocessor;

the said display, keyboard are in electrical connection with microprocessor.

7. Apparatus according to claim 6, wherein: the said measuring unit and display unit are separated as measuring apparatus and display apparatus physically; the said foot-on electrode plates, capacitance grid sensor, the said positive feedback RC oscillator circuit, weighing sensor, weighing signal processing circuit and the microprocessor of measuring apparatus are all positioned on the measuring apparatus; keyboard, display and the microprocessor of the display apparatus are all positioned on display apparatus.

8. Apparatus according to claim 6, wherein: in the circuit for measuring dielectric constant of body endermic tissues in the said positive feedback RC oscillator circuit and for measuring dielectric constant of body endermic tissues, one end of the capacitance grid sensor Cm is connected with one end of capacitor Ca; the other ends of the Cm and the Ca are respectively connected with the output end of one invertor and input end of the other invertor; resistor Ra is in series connection with body impedance Rm, and the other ends of the series circuit are respectively connected with the input end and the output end of one invertor; the input end of one invertor is connected with the output end of the other invertor.

9. Apparatus according to claim 6, wherein: in the circuit for measuring body impedance in the said positive feedback RC oscillator circuit and for measuring body impedance, the input end of one invertor is connected with the output end of the another invertor; between the joint of the two invertors and the input end of the other invertor, the series-wound circuit comprised by resistor Ra and body impedance Rm is introduced; the two ends of the capacitor Ca are connected respectively with the two invertors' two ends which are not connected with each other.

10. Apparatus according to claim 6, wherein: in the circuit for measuring body impedance in the said positive feedback RC oscillator circuit and for measuring body impedance, body impedance Rm is in series connection with resistor Ra1 and then in parallel connection with resistor Ra2; the one end of the circuit in series-parallel connection is connected with the invert end of the D trigger; and the other end is connected with the CD end, CLK end, and GND end of the D trigger.

11. Apparatus according to claim 6, wherein the said capacitance grid sensors are composed of two non-intersectant electrodes.

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12. Apparatus according to claim 6, wherein the said capacitance grid sensors are composed of the two groups of dentiform, nested and non-intersectant electrodes.

13. Apparatus according to claim 6, wherein: the said capacitance grid sensors are composed of two groups of electrodes which are equidistant and circle outward from the circular or rectangular center; and the two groups of electrodes are never intersectant.

14. Apparatus according to claim 6, wherein the said capacitance grid sensors are composed of electrodes that are connected by conductors to become two equidistant and non-touching electrode groups.

15. Apparatus according to claim 7, wherein: the said measuring apparatus includes infrared signal emitting circuit; electrical signal is input from the base electrode of audion T1; the collectors of audion T1 and T2 are connected with one port of infrared emitter (36); and the other port of infrared emitter (36) is connected with current-limiting resistor R1; infrared emitter (36) emits real-time infrared data signal (7); infrared receiver (38) receives the infrared instruction signal emitted by the said display apparatus which is converted to electrical signal and then transmitted from infrared receiver (38) to the base electrode of audion T3; the collector of audion T3 is connected with the input level of decoder (37); the output level of decoder (37) is connected with MCU system (20) of the measuring apparatus.

16. Apparatus according to claim 7, wherein: the said display apparatus includes infrared signal transmitting circuit; electrical signal is transmitted from infrared receiver (29) to the base electrode of audion T7; the collector of audion T7 is connected with the interface of MCU system (31) of the display apparatus; the interface of MCU system (31) of the display apparatus sends electrical signal to the input interface of encoder (39), whose output interface is connected with the base electrode of audion T5; the collectors of audion T5 and T6 are connected with one port of infrared emitter (33); and the other port of infrared emitter (33) is connected with current-limiting resistor R4; infrared emitter (33) emits infrared instruction signal (7).

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Abstract

A method for measuring dielectric constant of body endermic tissues and body impedance based on the method of frequency digital sampling and for evaluating body composition,
inputting through the I/O interface of a microprocessor the measured body weight frequency signals, oscillating frequency signals related to dielectric constant of body endermic tissues and body impedance signals corresponding to non-fixed different frequencies,
calculating through the software of the microprocessor the body fat content, total body water, ratio between intracellular water and total body water and
displaying the body weight, body fat content, total body water and ratio between intracellular water and total body water on the display;

a body composition monitor based on above method unit, which comprises weighing sensor and weighing signal processing circuit, and display unit.

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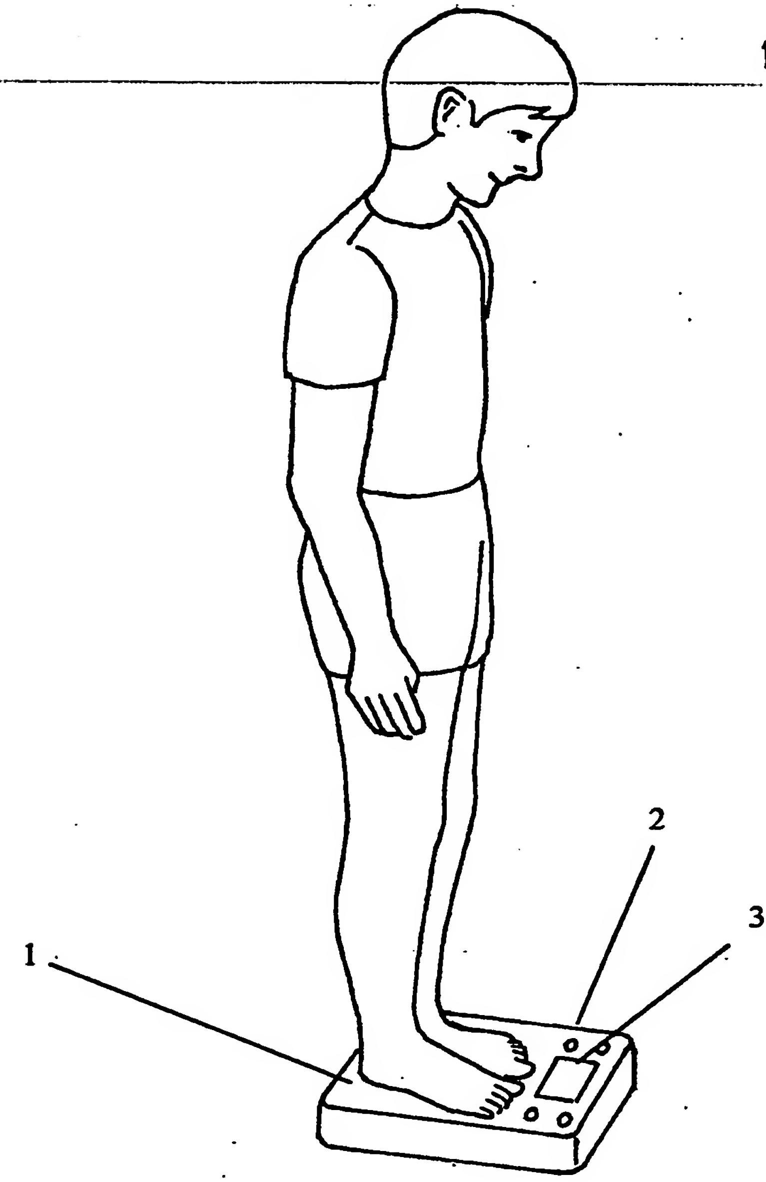

Fig 1A

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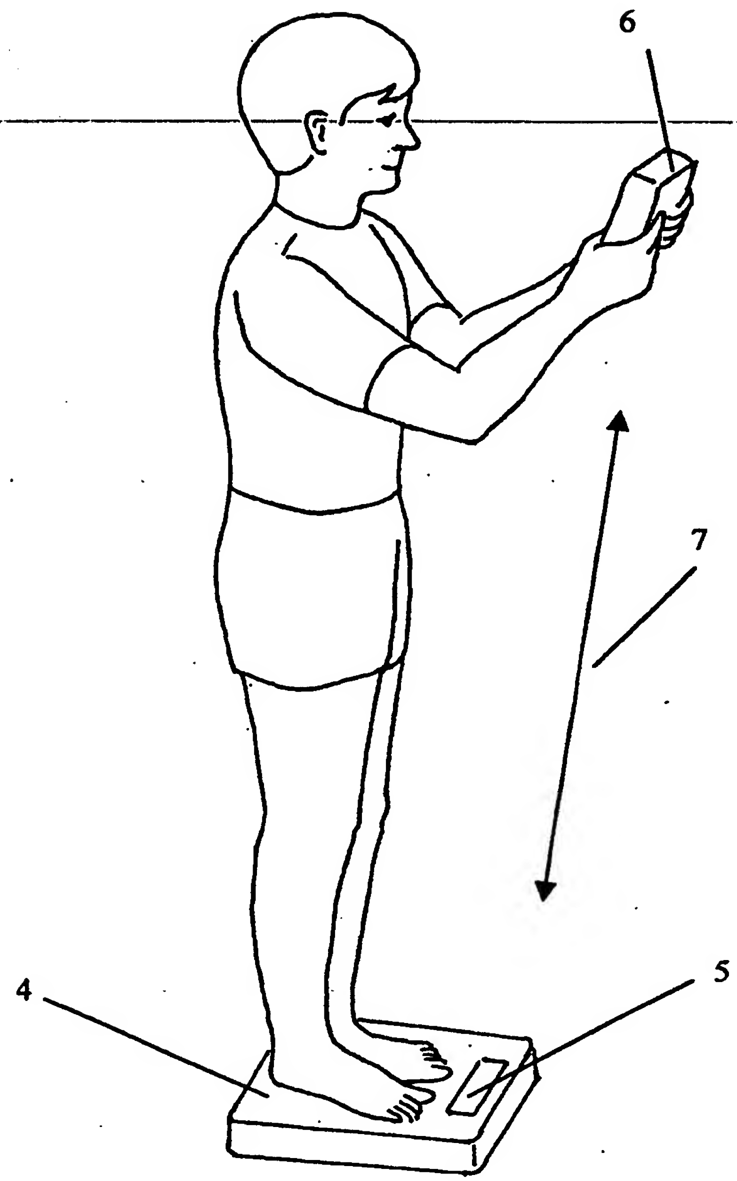

Fig 1B

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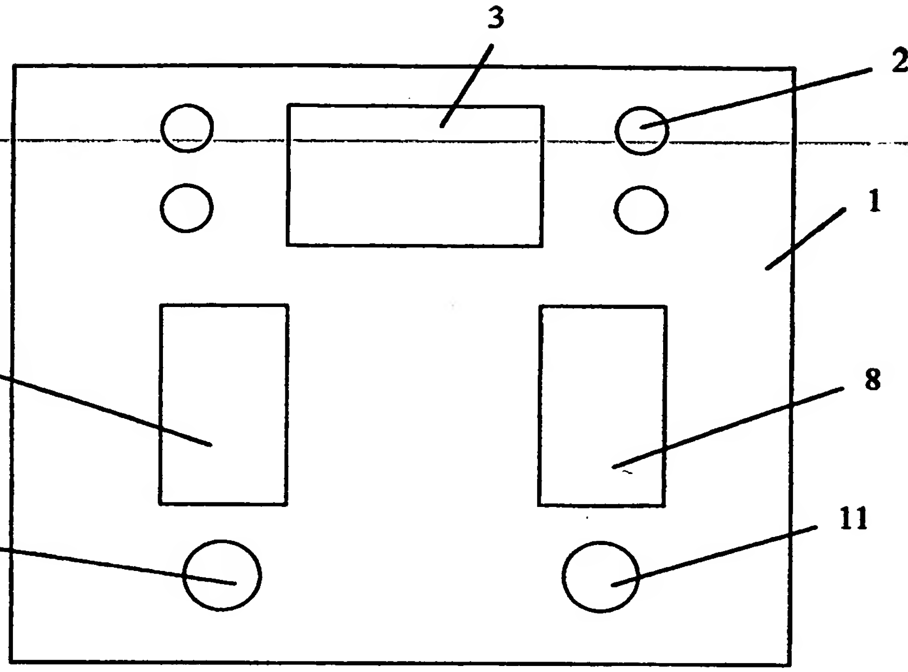

Fig 2A

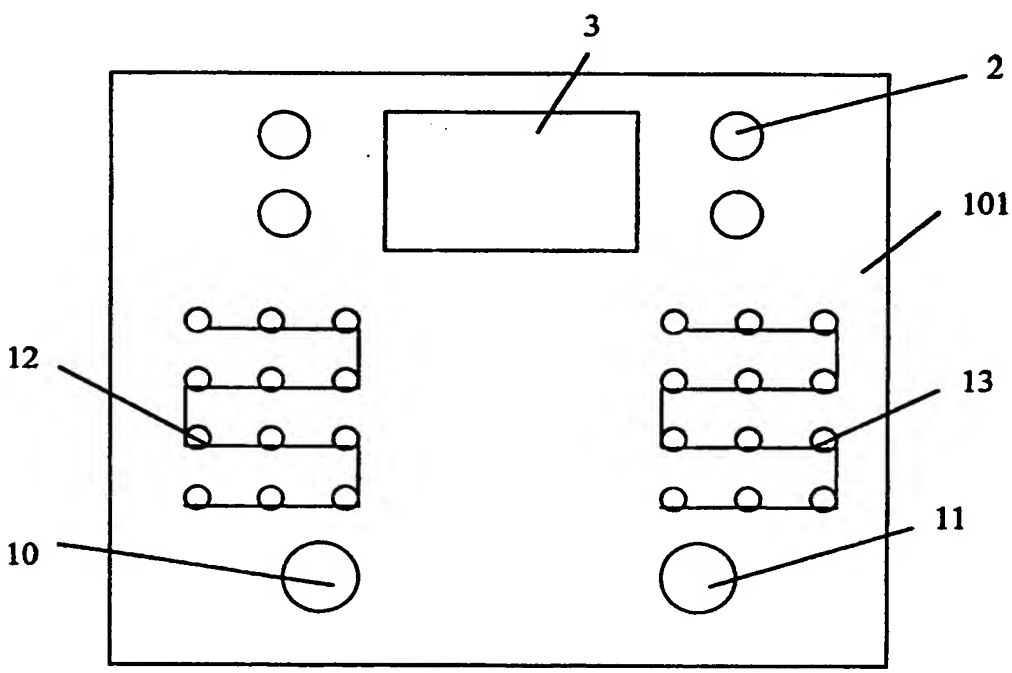

Fig 2B

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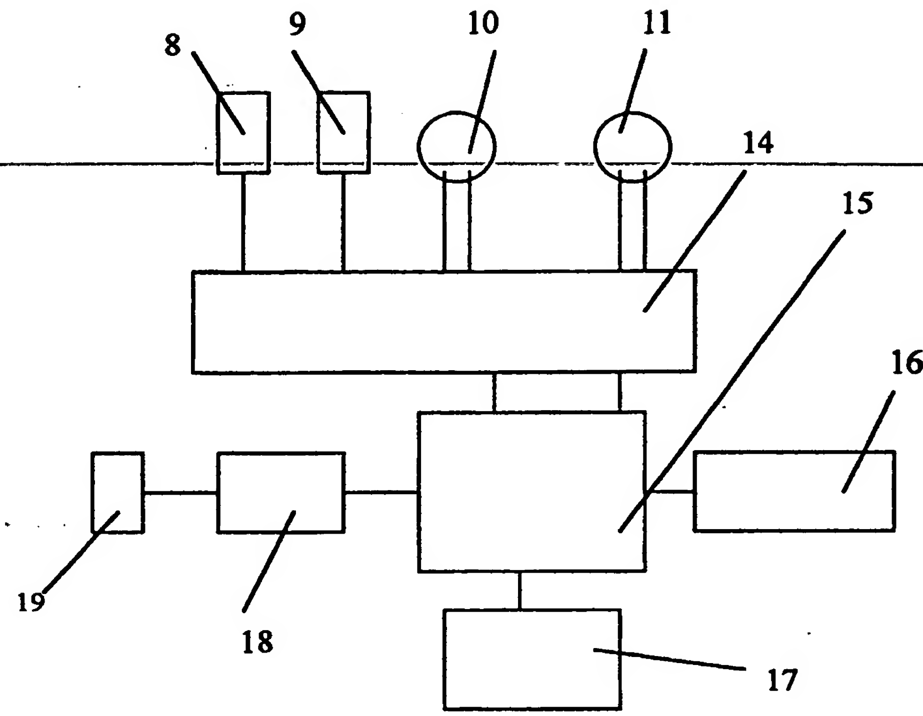

Fig 3A

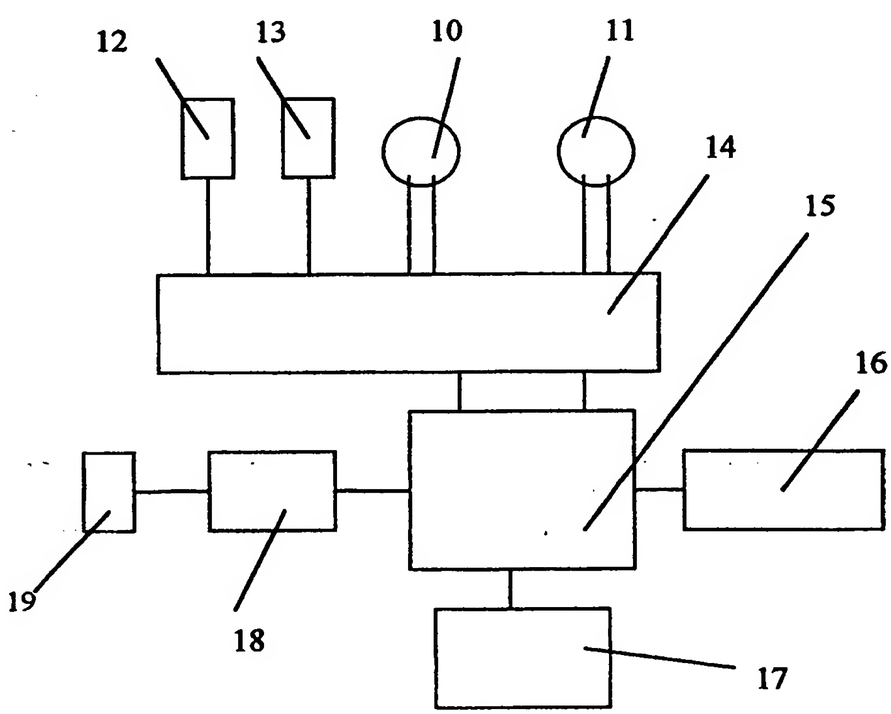

Fig 3B

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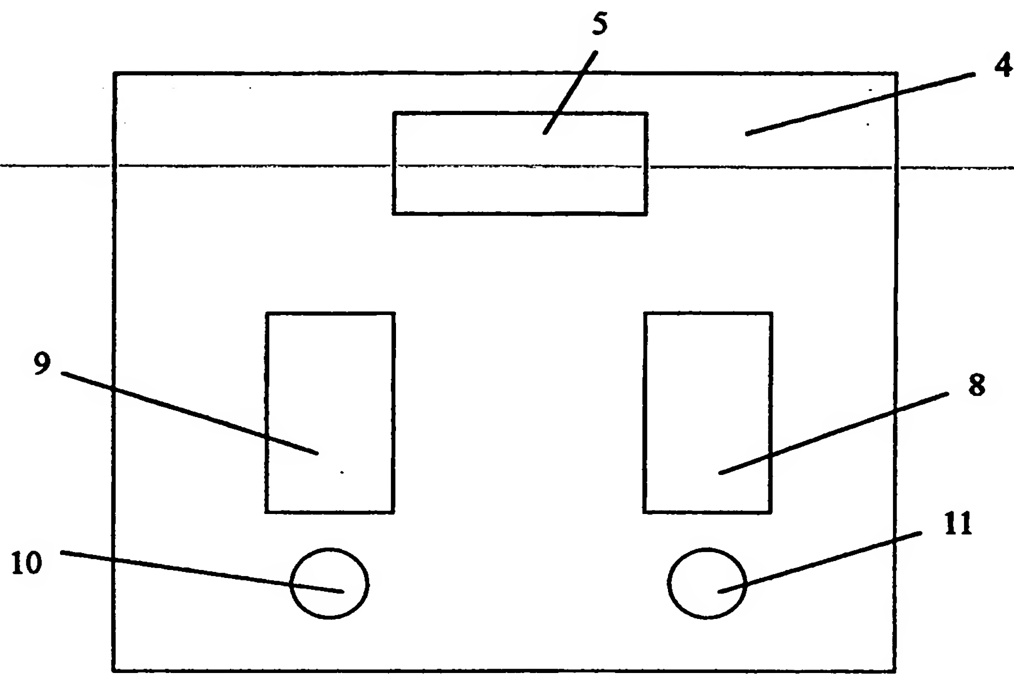

Fig 4A

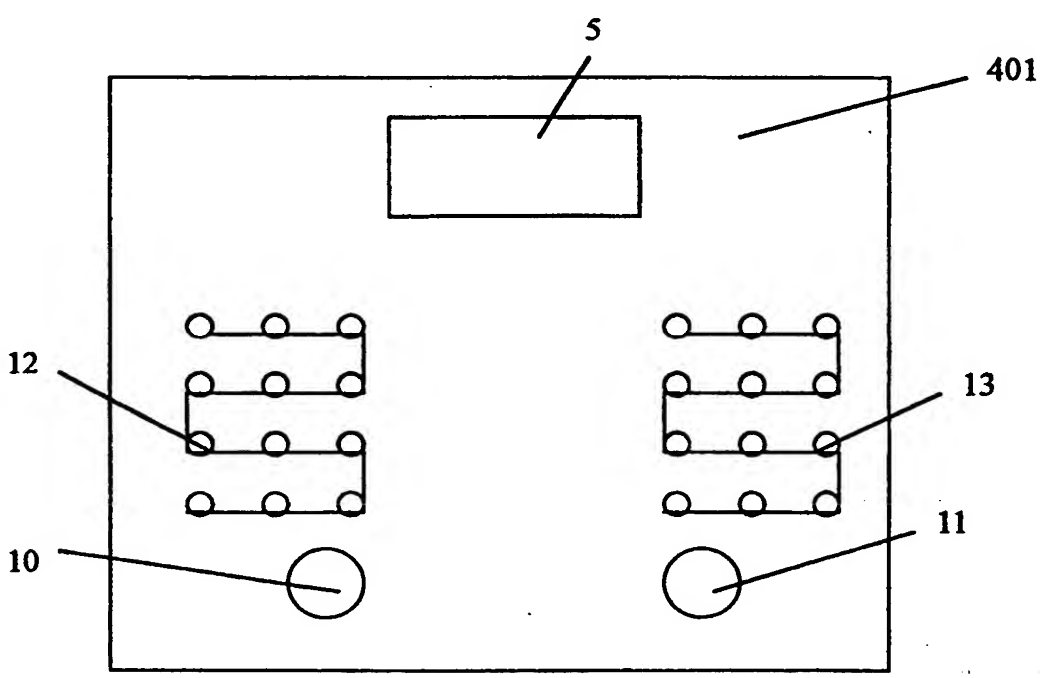

Fig 4B

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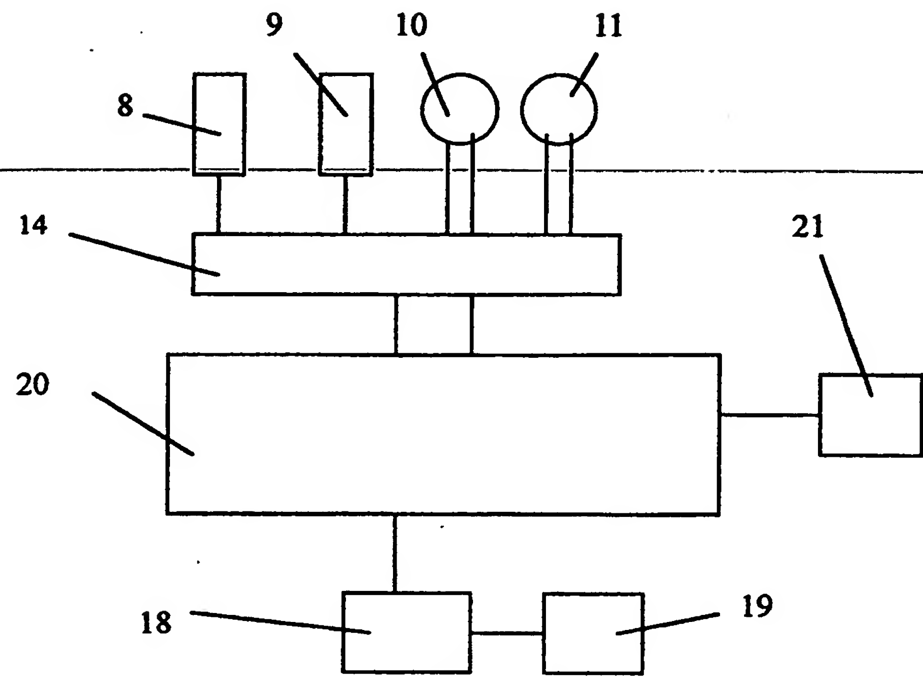

Fig 5A

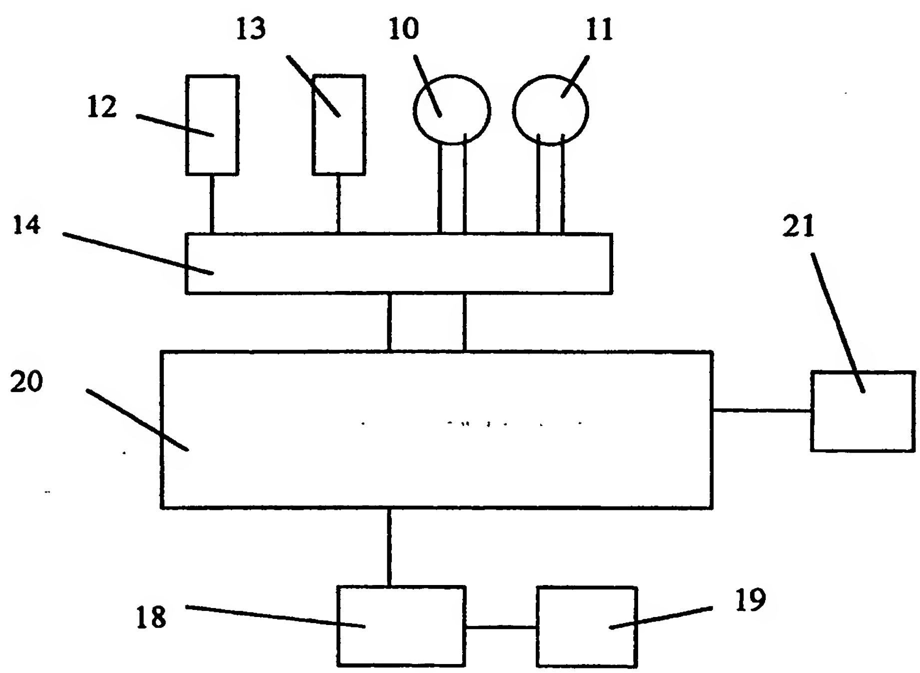

Fig 5B

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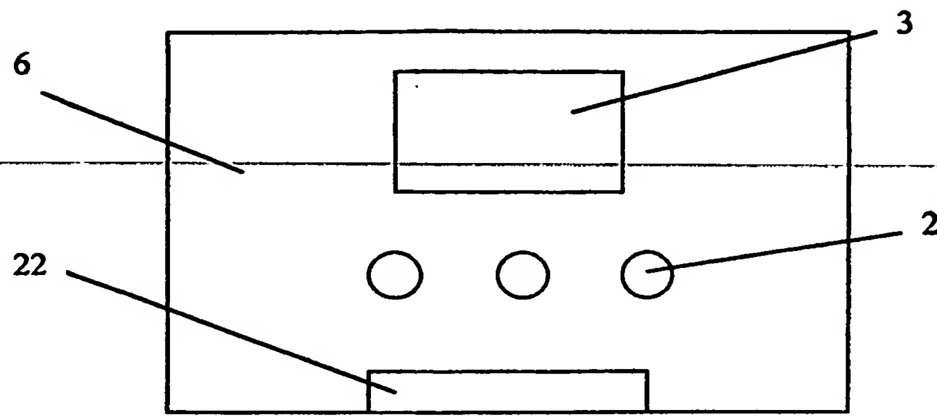

Fig 6

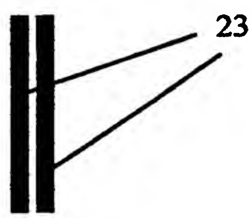

Fig 7A

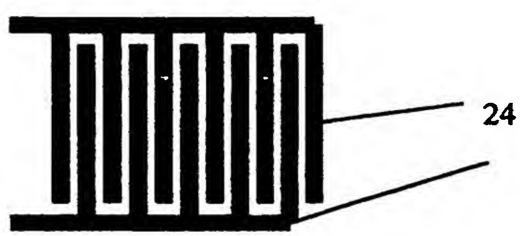

Fig 7B

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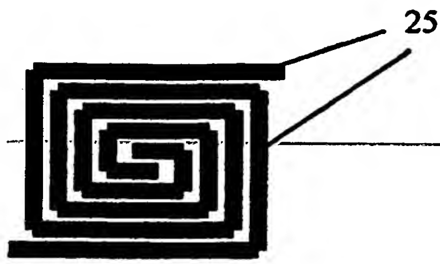

Fig 7C

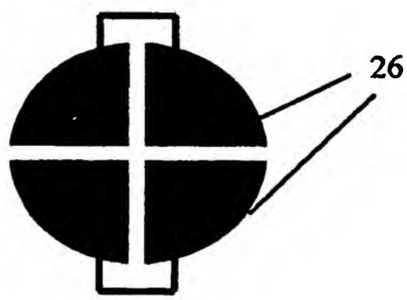

Fig 7D

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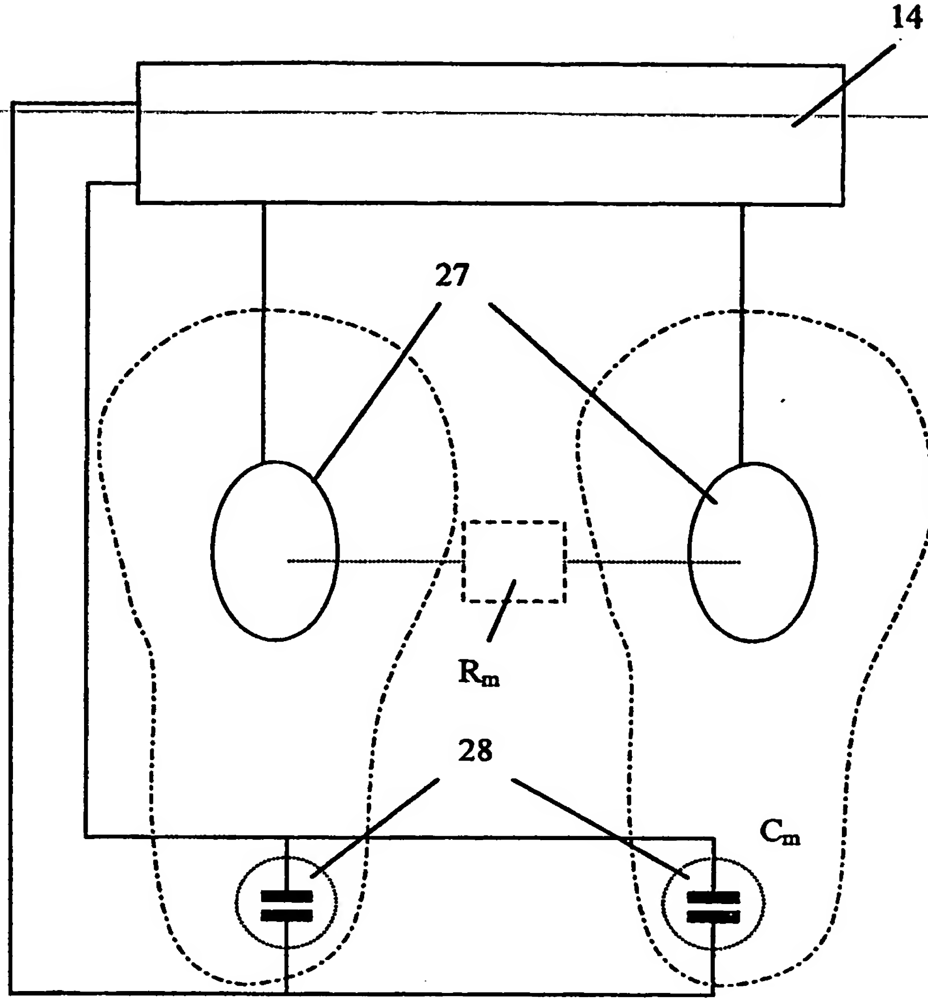

Fig 8

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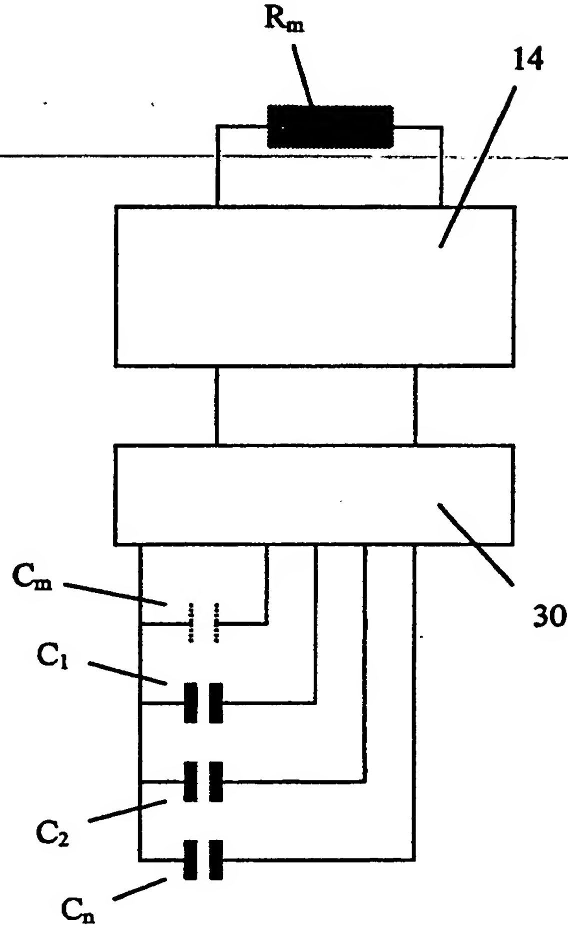

Fig 9

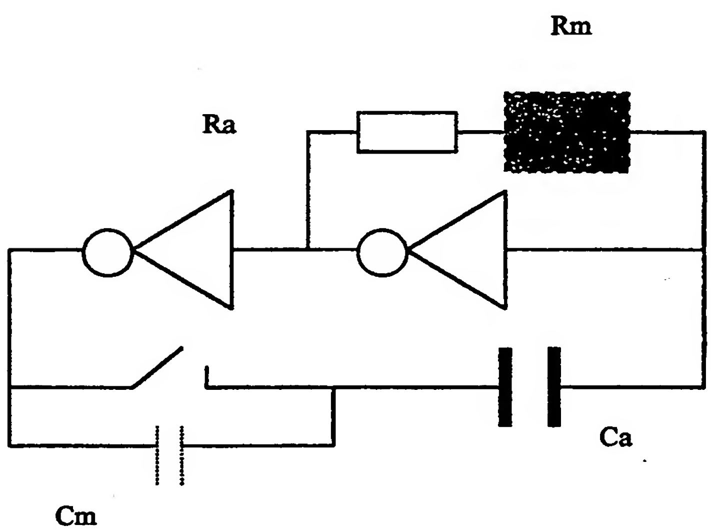

Fig 10

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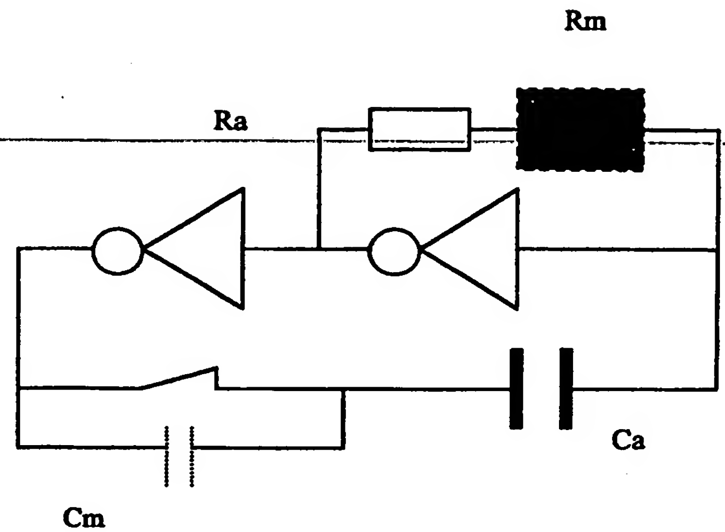

Fig 11

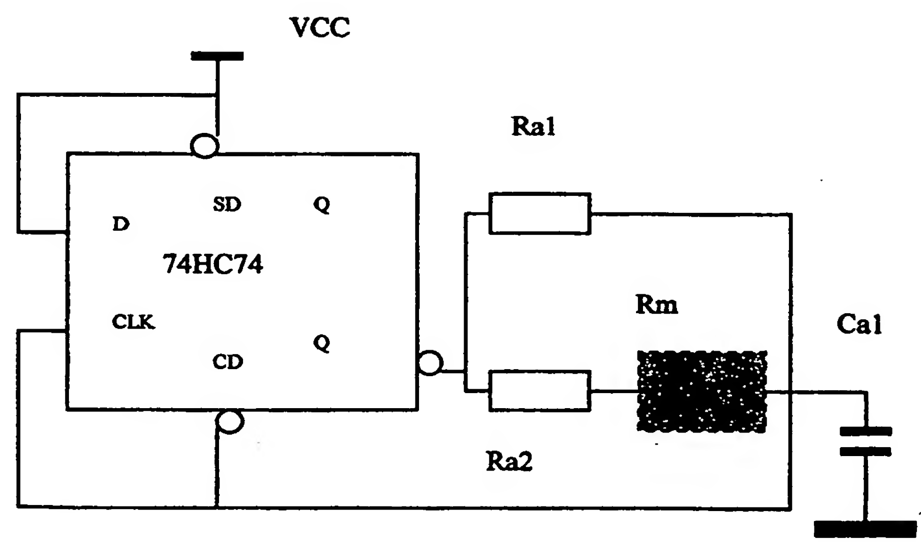

Fig12

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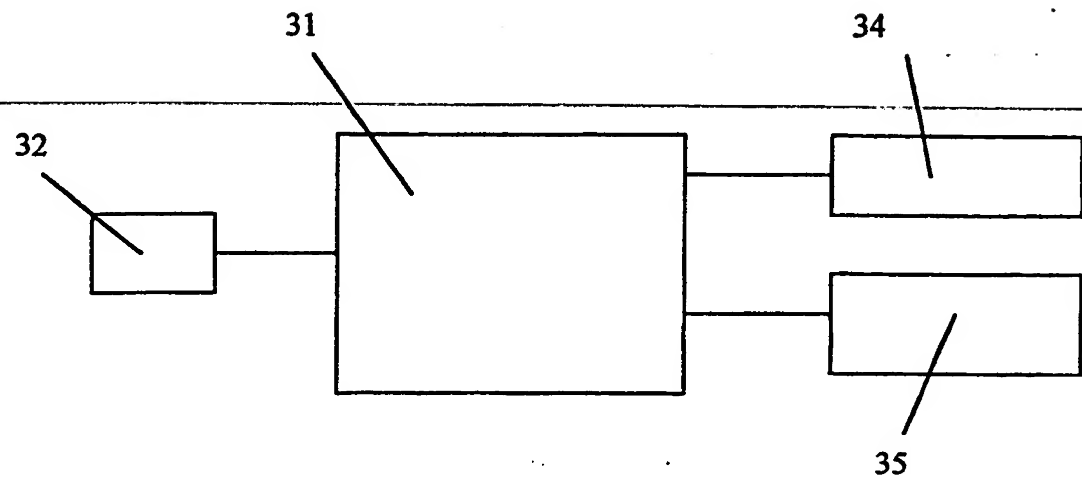

Fig 13

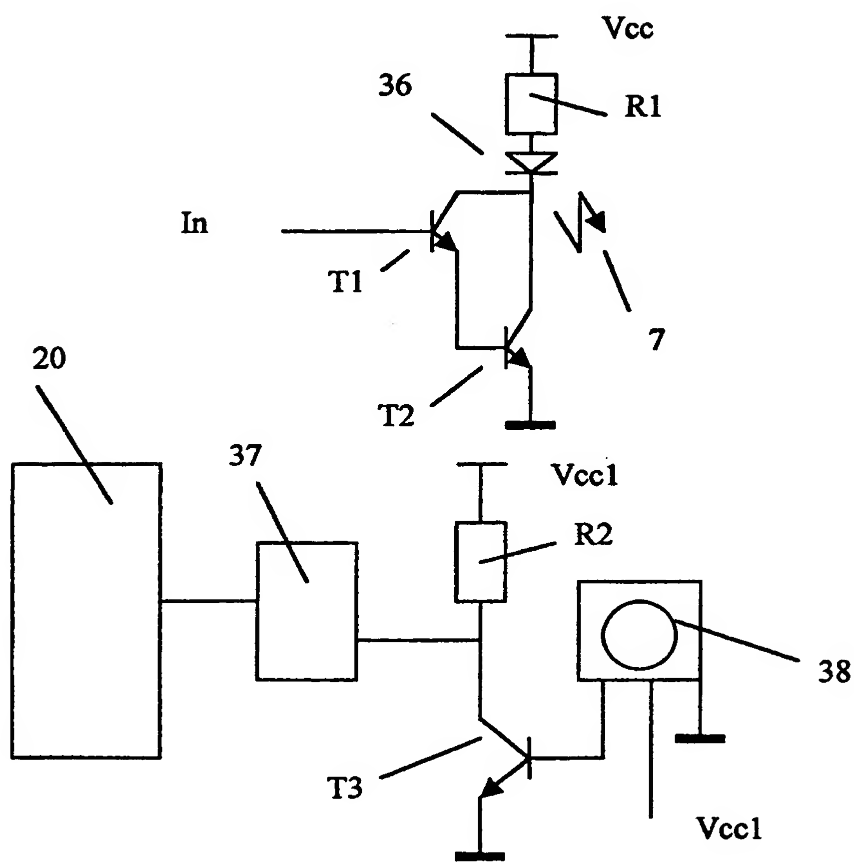

Fig 14

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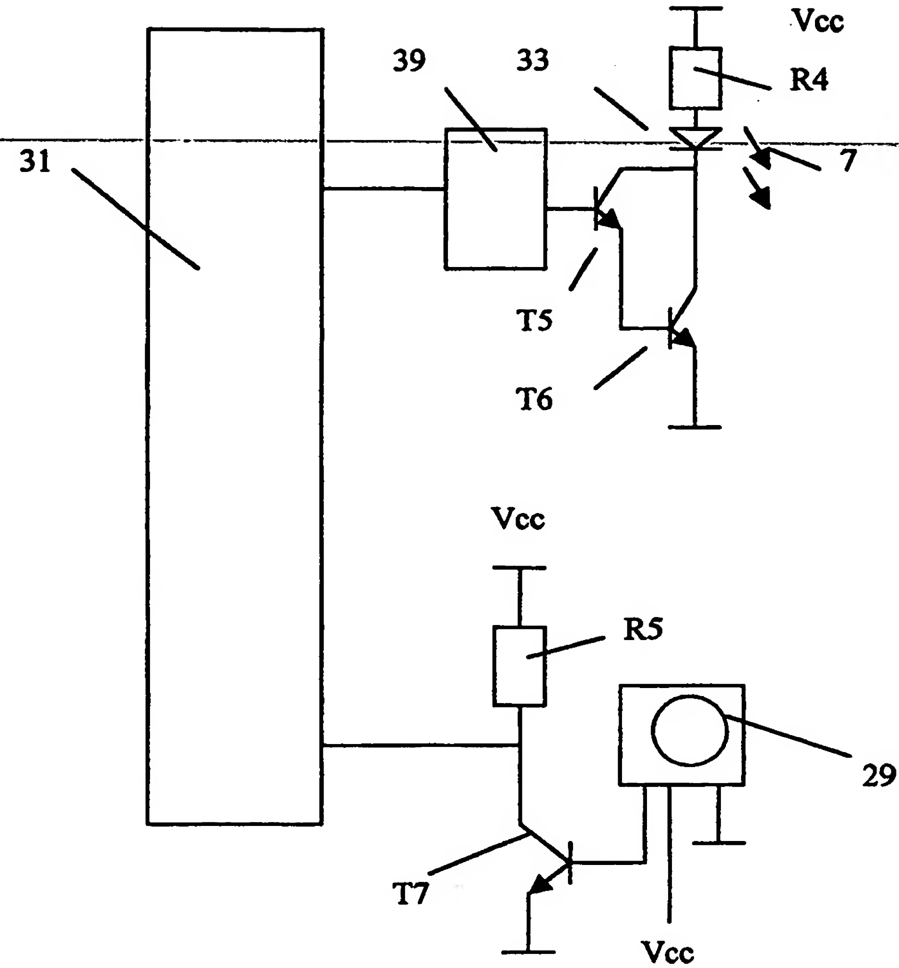

Fig 15

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